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FRICTION STIR WELDING AND PROCESSING

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Abstract

Friction stir welding (FSW) is the process of joining a relatively new solid-state. This joining method energy-efficient, environmentally-friendly and versatile. In particular, it is difficult to weld by conventional fusion welding, which can be used to join the high-strength aerospace Al alloy and other metal alloys.

This paper uses frictional heat and a non-consumable rotating welding equipment to produce plastic deformation went invented by The Welding Institute (TWI) in 1991 Stir friction welding (FSW) which focuses welding position; In addition, the material to affect the formation of a joint in a solid state. Understanding of FSW and Friction stir processing (FSP) and the current state of development is addressed. Particular emphasis has been: (a) Mechanisms responsible for the formation of the weld and micro-structural refinement, and (b) the resulting microstructure and FSW / FSP effect of parameters on the final mechanical properties. At this stage, technology diffusion has largely overcome the basic understanding of the micro-structural development and microstructure-property relationships. FSW certain industrial applications FSWa leap in manufacturing technology, aerospace, shipbuilding and auto industries are also presented.

Introduction

Friction stir successful implementation of Welding (FSW) is dependent on the implementation and control basic metal fundamentals locally. Join FSW thermal and mechanical system similar to those found in processes that work to other metals such as rolling, extrusion and forging. However, unlike the

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bulk Thermo Mechanical (TM) processing functions, to the highly localized nature of joint line FSW and also with vertical thermal and introduces distortion gradient. Therefore, the friction stir technologies must be to address the need for standards and specifications and should account for localized metalworking nature of friction stir technologies.FSW invented a solid-state The Welding Institute (TWI) in 1991 was as joining techniques in the UK, and it was applied to aluminum alloys initially. The basic concept of FSW remarkably simple. Special are designed pins and add a nonconsumable rotating tool with shoulder can be combined with the line or the picture is inserted into the abutting edges of the sheets or plates to trace.

Equipment movement of two primary functions: (a) work piece heating, and materials to produce composite (b). Heating between pieces of equipment and work carried out by plastic deformation of the pieces of friction and work. Localized heating soft material around the pin and the device is rotation and movement of materials in conjunction with the combination to the back pin from the pin. As a result of this process is to produce composite solid.

Various geometric characteristics of the equipment, the speed of the material around the pin can be quite complex. During FSW process, the resulting material undergoes intense plastic deformation at high temperatures, the right and the same set of recycled food. Friction stir produces finer microstructure good mechanical properties of the weld.

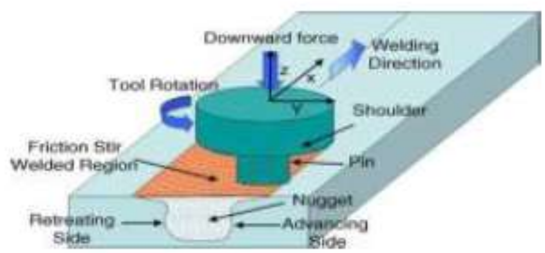

Figure 1. Schematic drawing of friction stir welding.

In FSW, is rotated to a profiled pin with cylindrical shoulders of the tool and is submerged in the joint area between two pieces of sheet or plate material. A part to prevent separation of the joint faces is protected as required by hugging. To soften without wear resistant welding tool and work to reach frictional heat melting the pieces, causes enable the latter to cross with tools weld line.

Toolgeometry

In FSW welding tool design is important. Greater or more efficient "stirring adaptation two main benefits of the tool geometry to achieve" generated heat: the oxide layer and more efficient breakdown of heat output and improved mix, high welding speed and of course, enhanced quality.

Table 1. Different alloys forging temperature range.

Alloy	Temperature range in °C
Al	440-550
Magnesium	250-350
Copper	600-900
C and low-alloy steels	650-800
Ti	700-950

Sense of growing experience and material flow with some improvements, tool geometry has been developed significantly. Changing material flow is added to complex features to reduce the mixing and process loads. For example, Whorl TM developed by TWI and MX Triflute TM device shown in Figure 2.

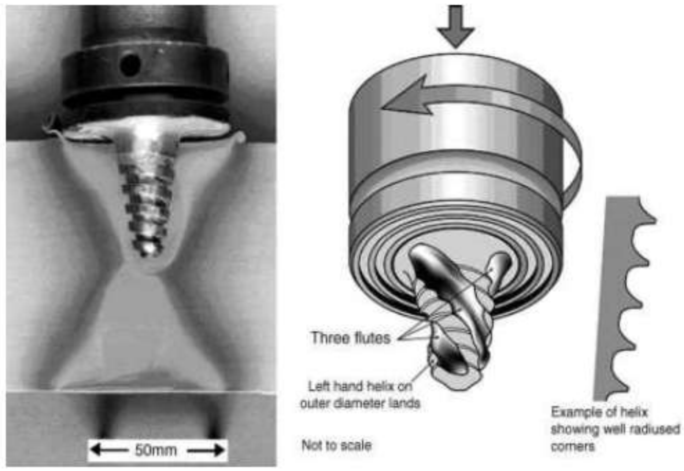

Figure 2. WorlTM and MX TrifluteTM tools.

Welding Parameter

To provide proper contact and thus ensure a high quality weld, the most important control feature down force (Z-axis). This may occur tolerance errors in the material to be guarantees of high quality even where included. This will ensure the friction heat generation to soften also enables tight control, because the content of the material during the high welding speed. When using FSW, should control the following parameters: the force, welding speed, welding equipment, rotation speed and tilt angle. Making it ideal FSW for mechanized welding is only required to master the four main parameters. The key process parameters axis with respect to the surface of the work piece or tool angle of inclination. A suitable tilt of the axis of the trailing direction it keeps ensured that stirred by side threaded pin tool material and move materials efficiently backwards in front of the pin. Thus, rotating shoulder stir the ingredients cannot be transferred efficiently to the rear to the front of the pin, resulting in weld generation with internal channel or groove surface. When the insertion depth is too deep, the tool's side fell in pieces excessive flash work making. In this case, is used to produce a substantially concave weld, which is local thinness of welded plates. It should be noted that allows being scrolling tool 08 tool tilt FSW recent development of the shoulder. Such tools are preferred for particular winding joints. Something to preheat or cool the typical FSW processes may also be important. The high melting point materials such as steel and titanium or high conductivity such as copper may not be enough to soften the plastic material around the abrasive material may be generated by moving equipment stirring. Thus, it is difficult to produce a continuous defect-free weld. In these cases, the preheating can help raise additional external heating source material flow and processing window. On the other hand, is less like the melting points in an area with significantly increases the use of aluminum and magnesium, cooling grains and stir and can be used to minimize the disruption to consolidate its surrounding areas.

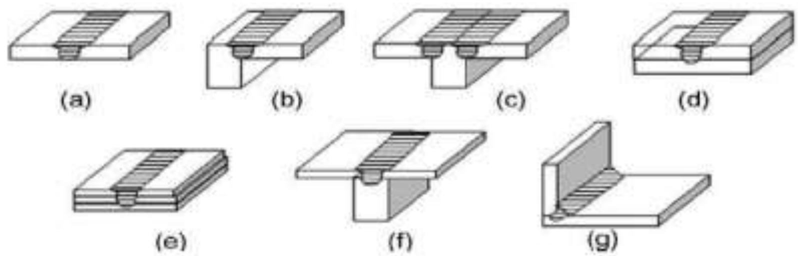

Figure 3. Joint configurations for FSW.

Joint Design

The convenient combined configuration butt and lap joints for FSW. A simple square butt is shown in combined Figure 3a. are placed two plates or sheets with the same thickness on a backing plate and jerky is pressing firmly to prevent it from separating joint faces. A rotating tool into the joint line and is in intimate contact with Travers used when the device side plates of the surface with this line, which produces weld with abting line. On the other hand, a simple lap joint is fastened on the backing plate two Laped plate or sheet. A rotating device through the upper plate and perpendicular to the bottom plate and is joined with the desired direction of the two plates (Figure 3d). Many other configurations are combining butt and lap joints can occur. In addition to the butt and lap joint configurations, joint design, such as fillet joints (Fig other types of 3g), are also required for some engineering applications.

Process Modeling

Metalflow

Friction stir material flow tool geometry during the welding process is quite complex, depending on the content of parameters and welded. Understand the material flow characteristics for optimum device design and practical importance for achieving high structural efficiency weld. It has been many investigations on material flow behavior during FSW. Tracer by several approaches, such as markers to visualize the material flow patterns in FSW technology, has been using welding of dissimilar alloys / metals. In addition, the material flow is also used in some computational methods including FEA to model.

Temperature distribution

FSW equipment and is the result of intense plastic deformation around rotating equipment and friction between the work pieces. These are within the scope of both factors stir and contribute surrounding temperature. Since influence within the movement area and the surrounding temperature distribution directly microstructure of welds, such as grain size, about the character of the range of grains, dissolution of precipitates and dissolution, and the resulting mechanical properties of the weld, temperature distribution it is important to achieve during FSW information. However, movement is very difficult due to intense plastic deformation produced by the temperature measurement device rotation and translation within the field.

Microstructural evolution

FSW is intense plastic deformation and restructuring and development of the structure within the bustling area contributed to high temperature performance within the raised area in the FSP and in the bustling area surrounding the possibility of dissolution and coarse. A posted structural change in various areas of the weld has significant effects on mechanical properties. Therefore, the study of micro-structural evolution during FSW / FSP has been used by many investigators.

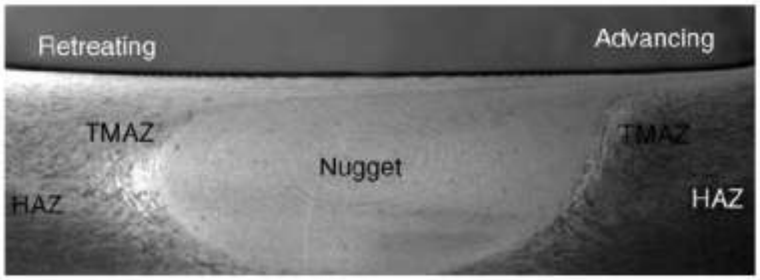

Figure 4. A typical macrograph showing different micro structural zones in FSP 7075Al-T651.

Shape of nuggetzone

Recently, an investigation on the impact of FSP parameter to cast a 356 microstructure and properties went to held. As a result of the results indicates that the lower tool rotation rate of 300-500 rpm basin-shaped nugget zone occurred while r 700 rpm (image by FTP. 5) High tool which elliptical Nugget zone on rotation. This indicates that may be produced, processing parameters of various Nugget shapes change with the same tool geometry.

Grainsize

It is precisely in the nodal zone as a result of dynamic restructuring during well accepted that FSW / FSP and create equal grain. FSW / FSP material put significant impact on the size of the composition of the pieces of equipment geometry, work, work piece temperature, vertical pressure, and active cooling FSW / FSP restructured grain content.

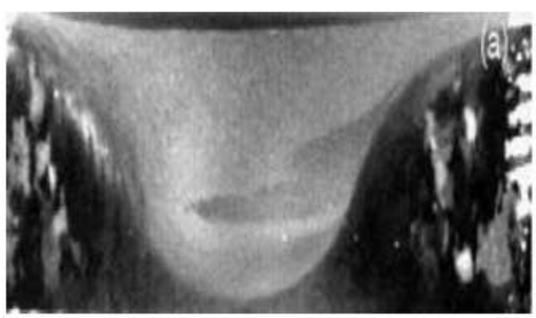

Figure 4(A)

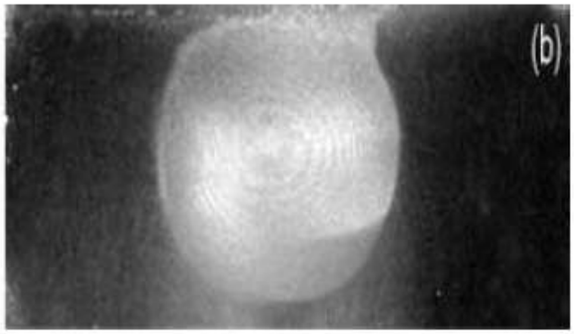

Figure 4(B)

Recrystallization mechanisms

Aluminum has many mechanisms for dynamic recrystallization process alloys have been proposed, such as closing dynamic recurrence (DDRX), constant dynamic recycling (CDRX), and geometric dynamic recalculation (GDRX). Due to the recovery because of high stacking - fault energy of aluminum high rates are not passing from aluminum and its alloys usually DDRX. However, particle-simulated nucleation of DDRX is celebrated in the large (> 0.6 mm) alloys with higher stages. DDRX featuring nucleation new grain on the old high-angle boundaries and gross grain boundary migration. On the other hand, CDRX commercial super plastic aluminum alloy and two-phase has been widely studied in stainless steels. Several mechanisms of CDRX receive a high false orientation angle of the turn have been proposed to sub-grains turn and stay a little range. For example, the system includes sub-grain growth, lattice associated with associated with the sliding mesh rotation and counter rotation.

Thermo-mechanically affected zone

During TMAZ FSW / FSP temperature and experience of both pathology. TMAZ Figure 5 has shown a typical micrograph of TMAZ is characterized by a highly distorted structure.

Enlarged the original metal grains were deformed in an upward-flowing patterns around the Nuggets. Although pass TMAZ plastic deformation, due to insufficient deformation stress was not recalculated in this area.

However, due to high temperatures during FSW / FSP, is shown in fig, as was seen breaking down some Avkshepon in TMAZ. Limit the disruption is, of course, depends on the thermal cycle experienced by TMAZ. In addition, it is believed that grain TMAZ is usually a high density of sub-limits.

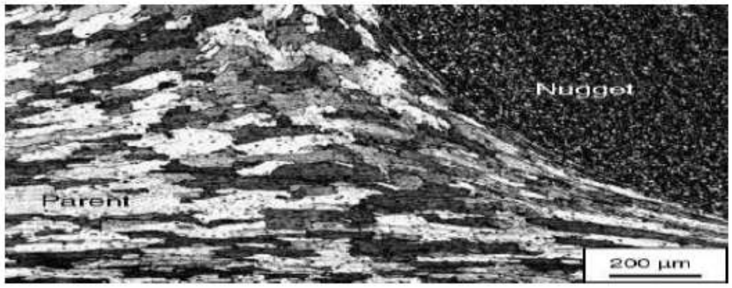

Figure 5. Microstructureiof thermomechanically affected zone in FSP 7075Al.

Heat-affected zone

A heat affected zone beyond TMAZ (HAZ). The region experiences a thermal cycle, but does not pass through any plastic deformation. Mahoney et al. HAZ is defined as heat-treatable area to experience more than 250 8C temperature rise for aluminum alloy. HAZ retains the grain structure of the original material. However, a significant impact on thermal exposure, precipitates structure above 250 8C.

Area of Application

Aero-space

- Space industries
- Civil aviation
- Aero-space Research and Development, Ship building

The following that panel manufacturer making the benefits of producing friction stir friction pre-welded panels:

- Specialty industrial production of high production to meet.
- To ensure a level playing field for extended level of replication, performance, quality and narrow tolerance.
- Allows customized solutions without compromising flexible production equipment and capacity distribution reliability.

• Full panel units have been approved by the inspection and DNV, RINA and Lloyd's Register's classification authorities.

• Panel ensures easy assembling in the yard of the high degree of straight, thereby reducing the need for manual welding.

Automotive Industry, Oil and Gas Industries, Nuclear and Refinery

Conclusion

Although it is only 14 years old as The Welding Institute (Cambridge, UK) in 1991 was invented FSW technology, has demonstrated some successful industrial applications FSW. The process have been demonstrated its capability and has been approved as a novel method for joining Al and other metals. FSW is opening up new areas of daily welding. Weld processes that allow the improvement of existing structural properties and leave the weld "cold". In some cases, if the same proper care, weld quality based content. Anyone working with aluminum which currently it is using FSW. Although currently widely used, it is within everyone's reach and promised to eliminate the specific smoke and flattened arc welding.

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